With this arrangement the Holmgren effect was not obtained, but yellow light did become red and green, both with and without a telescope, when the arrangement of the apparatus was inexact. It seems singular that Holmgren did not try the light of sodium in a Bunsen flame. With the sodium, lithium and thallium flame Hering was not able to obtain any change of color at all. He observed, what was known before, that yellow becomes white with diminished intensity, green very rapidly so, and red not at all. He observed also that weak blue points cannot be seen at all by direct vision (on account of absorption by the yellow spot), and that green and white points are strikingly brighter in indirect vision.

Holmgren says that white light might be tried, but that, "*der Kürze wegen*," he used only spectral light. There are certain points in nature which can be looked at in much shorter time than small holes lighted up by the spectrum,—they are the stars. Even when looked at through the telescope they present no change of color with change of position of the eye: it seems impossible that this should be the case if Holmgren's experiments were to be relied upon.

Hering's argument is not at all skillfully carried out, but nevertheless it seems to be quite conclusive against Holmgren's inferences. It does nothing to *disprove* the Young-Helmholtz theory of color sensation, though it would be very effective against it if it could be shown that the image on the retina had been shorn of its aberration circle. Helmholtz himself has said, however, that there is no reason for supposing that the three different sensations may not be three different activities in one and the same cone, and that the supposition of three cones is kept up merely for the sake of greater facility in speaking about the matter. CHRISTINE LADD-FRANKLIN.

Die Gesetzmässigkeit des Helligkeitscontrastes. H. EBBINGHAUS, Berlin. Sitzber. der K. Preuss. Akad. der Wissensch. zu Berlin, 1887, Sitzung vom 1. December. 15 pp.

To this very difficult topic of experimental psychology Dr. Ebbinghaus, whose study of the laws of memory is deservedly well known, makes a very valuable contribution. He succeeded in preparing a series of papers varying through shades of gray from the whitest white to the blackest black, and was able to get 53 such shades differing by objectively equal differences of brightness. The general tone of the grays was approximated to that produced by the rotation of pure black with pure white. He cut disks 2 cm. in diameter from these various papers, and placing a given disk on a background of its own shade, he found what shade of disk he had to place upon a background of a different degree of brightness in order that the two disks shall seem equally bright. It is evident that the difference in brightness of the two disks measures the amount of contrast. Working with great attention to details and with conditions analogous to those that the eye is subjected to in our every-day vision, he deduced from a large number of experiments the following laws: 1. Disks placed upon a background darker than their own shade of gray have their brightness *increased* by an amount that is closely proportional to the difference in brightness between disk and ground, but is independent of the absolute brightness of the ground. On the average the brightening by contrast is from one quarter to one fifth of the difference between disk and ground. 2. A disk placed upon a darker ground has its brightness *diminished* proportionally to

the difference between disk and ground taken independently of the absolute shade of the ground. In addition the darkening is dependent upon the brightness of the ground, being inversely as the brightness of this ground when the differences between disk and ground are equal. The amount of contrast is .3 of the difference between disk and ground, divided by the brightness of the ground. These laws yield the formulae, (1) $+c = K(h - H)$ where $h > H$, and (2) $-\frac{c}{h} = K'\frac{(h-H)}{H}$ where $h < H$; or $-c = K'(h - H)\frac{h}{H}$; where $+c$ indicates the brightening due to contrast, $-c$ the darkening, h the brightness of the disk, and H that of the background, K, K' constants depending on individuals and conditions. An interesting deduction from the second law is that the darkening by contrast has its maximum effect when the ground has upon it a disk of half its own brightness.

Lehmann had studied the problem of contrast with rotating disks, and Ebbinghaus is able to show that the first law is deducible from the former's results, his constant being .226. Of the second law, however, no trace is to be found in Lehmann's results, which is considered as due to unfavorable conditions of experimentation. By way of explanation of the phenomena the author believes the process to be in the retina itself, and supposes a change in sensitiveness of the different portions of the retina due to slight variations in the blood supply.

The second part of the paper is devoted to a test of Weber's law. If a series of shades be arranged, the ratios forming a geometrical progression, the intervals of brightness will not seem the same throughout the scale, as Weber's law demands, but both at the upper and at the lower ends the intervals will seem too small, while even in the medium portion slight differences can be detected. Conversely, if we arrange a series of shades that, as far as these papers allow us to do, seem equally different (the comparison being made pair by pair), we will not get an exact geometrical series. But if we have in mind only general approximate results we can say that within the limits of black and white, with which we ordinarily have to do, a series of subjectively equal intervals of sensations of brightness has objectively corresponding to it a geometrical series of light intensities. Dividing the field of shades into seven divisions, the ratio for passing from one to the other, from below upwards, was found to be 2.25, 2.11, 2.05, 1.77, 1.72, 1.68, 1.98. J. J.

Ueber die Unterschiedsempfindlichkeit für Tonhöhen. EDWARD LUFT. Philosophische Studien, IV, 4, 1888.

From the fact that we regard tone intervals as equal when the ratio of their vibration rates is the same, Fechner inferred that Weber's law is valid for sensations of musical pitch. The validity of this inference was questioned by Preyer, who suggested that this perception of the equality of intervals might be due to the occurrence of overtones and so on, and furthermore showed that the smallest perceptible difference in the pitch of two tones was not proportional to their vibration rate, but much more nearly approached constancy for all tones of a medium pitch. Luft subjects the results of Preyer and others to a fair and discerning criticism, and makes a series of observations in which care was taken to have the tones equal in intensity, the latter being the point in which Fechner saw the weak-